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ECHOSOUNDER

Echo-sounder sends an acoustic pulse directly downwards to the seabed and records the returned echo. The sound pulse is generated by a transducer that emits an acoustic pulse and then "listens" for the return signal.

The time for the signal to returns recorded and converted to a depth measurement by calculating the speed of sounding water. As the speed of sound in water is around 1,500 meters per second, the time interval, measured in milliseconds, between the pulse being transmitted and the echo being received, allows bottom depth and targets to be measured. The value of underwater acoustics to the fishing industry has led to the development of other acoustic instruments that operate in a similar fashion to echo-sounders but, because their function is slightly different from the initial model of the echo-sounder, have been given different terms.

Echosounders use the following principle: a projector generates sound waves and a receiver or hydrophone receives the echo. If the transmitter is able to both produce and receives sound waves, this is referred as a transducer. Based on the travel time or the energy of the reflected waves, the respective depth or bottom type can be assessed. Obviously, the results depend upon the emitted frequencies. Low frequencies are less absorbed and are thus able to reach further than high frequencies. This is why low frequencies can be used to monitor a big area but with a lower resolution (low quality).

The methods to obtain the seabed :

(Figure by VLIZ : Working principle of the multibeam)

Multibeam Echosounder

Multibeam echosounder systems (MBES) first appeared in the 1970 sand primarily consisted in an extension of a single beam echosounder. Echosounders are capable to transmit a pulse of controlled length, repetition rate and frequency to an underwater acoustic transducer and to accurately time the returning echoes (propagation velocity of sound waves in water: ~1,500 m/s). Instead of transmitting and receiving a single vertical beam, the MBES transmits several tens of beams (typically 100 to 200) with small individual widths (1° to 3°) in the form of afar perpendicular to the navigation line. This configuration provides depth information's out to several hundred meters each side of the vessel which allows to survey large areas of the seabed with a higher density and a better accuracy than single beam echosounders. During recent years MBES have greatly evolved and nowadays they are a broadly accepted tool for seabed mapping. Acoustic transducers were developed with frequencies ranging between a few hertz and several megahertz depending on the region and the water depth surveyed. A low frequency of 12 kHz is used for deep sea research, whereas recently developed MBES with high frequencies between 200 and 300 kHz are applied for the investigation of shallow-water areas.

Seabed Classification System

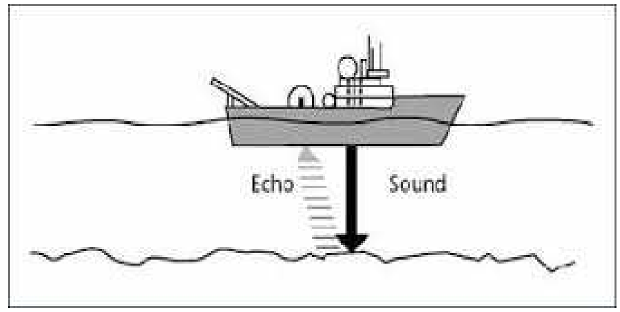
Conventional methods to classify the seabed are in situ sampling of bottom sediments or optical methods like analyzing of photos and videos. However, remote acoustic classification techniques are becoming of increasing importance because they are less expensive and time-consuming and provide a higher spatial resolution in determining the seabed characteristics. Especially, echosounder-based techniques, first developed for fishery purposes, are a useful tool to classify a big area of the seabed in a relative short time period with a high spatial resolution. In general, echosounders are used for bathymetric surveys. However, acoustic signals reflected by the seabed contain more information than just the water depth. The intensity and shape of a returning acoustic signal is affected by a number of factors, primarily sediment grain size and sorting, seabed roughness, bed forms, and presence, concentration and type of benthic fauna and flora. For instance, the harder or rougher the seabed, the more energy is scattered back to the transducer and vice versa. Therefore, echosounder-based classification systems are utilized to reveal geological structures of the seabed composed of various types of sediments and rocks.

QTC View

The QTC VIEW system uses the first returning echo from the seabed only and analyzes the shape of each echo with a series of five algorithms. These algorithms characterize the waveform by using energy and spectral components, yielding 166 descriptors of each echo. Principal-Component-Analysis (PCA) reduces the large quantity of information to three most useful descriptors (Q1, Q2, Q3), which prove enough to recognize the different types of seabed. Echoes of similar character form clusters that stand for distinct acoustic classes. To correlate each acoustic class with seabed characteristics ground trusting by sampling bottom sediments has to be carried out. The result is a georeferenced track plot classified by sediment types.

Side scan Sonar

A basic Side scan Sonar System consists of a topside processing unit, a cable for electronic transmission and towing, and a subsurface unit (a tow fish) that transmits and receives acoustic energy for imaging. Sides can sonar is a method of underwater imaging using narrow beams of acoustic energy (sound) transmitted out to the side of the tow fish and across the bottom. Sound is reflected back from the bottom and from objects to the tow fish. Certain frequencies work better than others, high frequencies (>500 kHz) give excellent resolutions but the acoustic energy only travels a short distance. Lower frequencies (50-100 kHz) give lower resolution but the distance that the energy travels is greatly improved. The tow fish generates one pulse of energy at a time and waits for the sound to be reflected back. The imaging range is determined by how long the tow fish waits before transmitting the next pulse of acoustic energy. The image is thus built up one line of data at a time. Hard objects reflect more energy causing a lighter signal on the image; soft objects that do not reflect energy as well show up as darker signals. The absence of sound such as shadows behind objects shows up as very dark areas on a sonar image.



(Figure by OIC : single beam echosounder)

Single Beam Echosounder

A single beam echosounder or 'depth sounder' is a system capable of accurately measuring the water depth below a vessel (Figure). This is achieved by measuringthe two-way travel time (e.g. from the ship to the seabed, and back again) of an acoustic pulse (or a burst of sound) emitted by the sonar transducer. The acoustic pulse typically ranges in frequency from 12 - 200 kHz, with lower frequencies required in deeper water. The reliability of the depth calculation is dependant on accurately knowing the sound velocity in sea water, which is usually around 1500 m/s depending on water temperature, salinity, and other factors. Single beam echosounders are routinely mounted on most sea-going vessels, and when attached to a GPS and recording device, provide an inexpensive seabed mapping tool.

Multibeam Sonars

A multibeam sonar operates much like a single-beam echo sounder, ensonifying the bottom and detecting echo arrival times. Unlike the single-beam sonar, which illuminates a single point beneath the sonar, the multibeam sonar illuminates a narrow swath elongated across the bottom and perpendicular to the path of the boat. This illuminated swath is then sampled with multiple, discrete "receive beams" formed by the sonar at known angles. For each beam, the sonar attempts to determine the "best" echo arrival time. With the known beam angle, the determined "best" echo travel-time, and the water-column sound velocity, the cross-track distance and depth can be determined.

Reference:

[1] Monier, Muhammed. Echosounder Types And How To Used It
[2] VLIZ. Multibeam Echosounder. Depestele, J. *et al.* (2015)

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